REMARKS

Applicants have amended Fig. 10 of the original disclosure, and have amended the specification in the paragraph bridging pages 30 and 31 thereof, to show/describe that the incident light waveguide (core portion) 7 has a curve portion with a radius **r** of curvature, the specification being amended to describe that this radius **r** of curvature is shown in Fig. 10. Noting Applicants' specification as originally filed, referring to the incident light waveguide 7 as having a curve portion, it is respectfully submitted that this amendment of Fig. 10 and corresponding amendment of the specification in connection therewith, do not add new matter to the application. Moreover, noting the objection to the drawings in Item 3 on pages 3 and 4 of the Office Action mailed October 18, 2007, set forth for the first time in the Office Action mailed October 18, 2007, it is respectfully submitted that the amendment of Fig. 10 and corresponding amendment to the specification are proper and materially limit issues remaining in connection with the above-identified application, do not raise any new issues including any issue of new matter, and should be entered notwithstanding Finality of the Office Action mailed October 18, 2007.

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended each of claims 1 and 2 to recite that the intensity distribution of light entering from at least one optical waveguide (a), of the at least one incident light waveguide (A), into the multi-mold optical waveguide, is asymmetric with respect to a geometrical central axis of the at least one optical waveguide (a). It is respectfully submitted that this amendment to each of claims 1 and 2 clarifies the recitation in connection therewith, and does not in substance change the subject matter thereof.

Applicants have also amended each of claims 9 and 17 to recite at least one of the core "and" a clad in line 2 thereof; and have amended each of claims 8 and 16 to recite at least one of the at least one incident light waveguide (A) "and" the output light waveguides (B). Noting use of "at least one of" in claims 8, 9, 16 and 17, it is respectfully submitted that the present amendments of these claims provide the claims in better grammatical form.

Furthermore, Applicants have amended each of independent claims 21 and 25 to incorporate therein respectively the subject matter of claims 22 and 26, reciting that the at least one optical waveguide (a) is a curved optical waveguide. In light of these amendments to claims 21 and 25, Applicants have cancelled claims 22, 23, 26 and 27 without prejudice or disclaimer.

Initially, reconsideration and withdrawal of the Finality of the Office Action mailed October 18, 2007, are respectfully requested. In this regard, the rejection of claims under the second paragraph of 35 U.S.C. §112, set forth in Item 6 on page 3 of the Office Action mailed May 8, 2007, is noted. This rejection was due to an alleged incompleteness of original claims 1-18, the Examiner contending that there is no structural element that would cause the intensity distribution of light to be asymmetric. In view thereof, Applicants amended their claims to recite that the at least one optical waveguide (a) has a curved structure. It is respectfully submitted that the Examiner should reasonably have known that Applicants would be amending their claims to recite the curved structure of the at least one optical waveguide (a), in light of this rejection under the second paragraph of 35 U.S.C. §112. Notwithstanding this, with Applicants amending their claims to recite that the at least one optical waveguide (a) has a curved structure, the Examiner has issued a new rejection of Applicants' claims under 35 U.S.C. §102 and 35 U.S.C. §103, using a new reference (U.S. Patent No. 5,664,938 to Okushima), while making this Office

Action a Final rejection. It is respectfully submitted that such finality is improper, in light of new application of Okushima, of claims which were amended as would have been clear to the Examiner. See Manual of Patent Examining Procedure 706.07(a), stating that a "second or any subsequent action on the merits in any application...should not be made final if it includes a rejection, on prior art not of record, of any claim amended to include limitations which should reasonably have been expected to be claimed".

In any event, even assuming, arguendo, that the Finality of the Office Action dated October 18, 2007, were proper, it is respectfully submitted that entry of the present amendments is proper under 37 C.F.R. §1.116. Clearly, the amendments to the drawings and corresponding amendments to the specification simplify issues in connection with the above-identified application, by overcoming the objection to the drawings set forth for the first time in the Office Action mailed October 18, 2007; and clearly do not raise any new issues, including any issue of new matter, reference being made to the paragraph bridging pages 30 and 31 of Applicants' specification, for example. In addition, by incorporating subject matter of previously considered dependent claims into independent claims, and by providing the claims in more appropriate English, the present amendments materially limit issues remaining in the above-identified application, with respect to the claimed subject matter, at the very least presenting the claims in better form for appeal. As the present amendments incorporate subject matter of previously considered dependent claims into previously considered independent claims, it is respectfully submitted that the present amendments do not raise any new issues, including any issue of new matter.

In view of all the foregoing, it is respectfully submitted that Applicants have made the necessary showing under 37 C.F.R. §1.116(b); and that, accordingly, entry of the present amendments is clearly proper.

The objection to the drawings under 37 C.F.R. §1.83(a), set forth in Item 3 on pages 3 and 4 of the Office Action mailed October 18, 2007, is noted. In view of present amendments to Fig. 10, it is respectfully submitted that this objection to the drawings is moot.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the references applied by the Examiner in rejecting claims formerly in the application, that is, the teachings of the U.S. patents to Okushima, No. 5,664,038, and to Ido, No. 6,236,784, under the provisions of 35 U.S.C. §102 and 35 U.S.C. §103.

It is respectfully submitted that the teaching of these references as applied by the Examiner would have neither disclosed nor would have suggested such a light branching optical waveguide, or such optical device having such light branching optical waveguide, as in the present claims, including, inter alia, wherein the waveguide includes at least one incident light waveguide (A) optically connected to one end of a multi-mode optical waveguide, and output light waveguides (B), larger in number than the number of incident light waveguide(s) (A), optically connected to the other end of the multi-mode optical waveguide, wherein an intensity distribution of light entering from at least one optical waveguide (a), of the at least one incident light waveguide (A), into the multi-mode optical waveguide at a connecting surface of the at least one incident light waveguide (A) and the multi-mode optical waveguide, is asymmetric with respect to a geometrical central axis of the waveguide (a), the at least one optical waveguide (a) having a curved structure, and (i) an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode optical waveguide (see claims 1 and 3), and/or (ii) a core shape of the multi-mode optical waveguide is

asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide (see claim 2).

Furthermore, it is respectfully submitted that the teachings of the references as applied by the Examiner would have neither disclosed nor would have suggested such a method of manufacturing a light branching optical waveguide as in the present claims, the light branching optical waveguide having structure including the waveguides (A), (B) and (a), the at least one optical waveguide (a) having a curved structure, and including the multi-mode optical waveguide, as discussed previously, the method including positioning the at least one optical waveguide (a), which has the curved structure, such that an extended line of the geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode optical waveguide (see claim 21); or wherein the method includes forming a core shape of the multi-mode optical waveguide to be asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide (see claim 25).

As will be discussed infra, and contrary to the contention by the Examiner, it is respectfully submitted that Okushima does not disclose, nor would have suggested, such structure or method as in the present claims, including the at least one optical waveguide (a) which has a curved structure (i.e., is a curved optical waveguide); and would have neither taught nor would have suggested problems arising in connection therewith, and advantages achieved by the present invention.

Furthermore, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such light branching optical waveguide as in the present claims, having features as discussed previously in connection with claims 1-3, and, additionally, having features as in the dependent claims, dependent ultimately on claims 1 and 2, including, inter alia (but

not limited to), wherein an optical central axis having a peak intensity in the intensity distribution of light entering into the multi-mode optical waveguide from the at least one optical waveguide (a) substantially coincides with the geometrical central axis of the multi-mode optical waveguide (see claims 4 and 12); and/or wherein the core shape of the multi-mode optical waveguide has a notch at at least one of its side edges (see claims 5 and 13), particularly wherein such notch is obtained by a technique as in claims 6 and 14, especially with a shape of the notch as in claims 6 and 14; and/or wherein the at least one incident light waveguide (A) includes one incident light waveguide and the output light waveguides (B) include at least two output light waveguides, with a branching ratio between quantities of light branched into the at least two respective output light waveguides (B) being substantially equal (see claims 7 and 15); and/or wherein at least one of the at least one incident light waveguide (A) and the output light waveguides (B) include a single-mode optical waveguide (note claims 8 and 16); and/or materials of the core or clad of the multi-mode optical waveguide, as set forth in claims 9, 10 and 17; and/or offset distance between the extended line of the geometrical central axis of the at least one optical waveguide (a) and the geometrical central axis of the multi-mode optical waveguide, as in claims 19 and 20.

In addition, it is respectfully submitted that the teachings of the applied references would have neither disclosed nor would have suggested such a method as discussed previously in connection with claims 21 and 25, and including additional features as in claims dependent on claims 21 and 25, including (but not limited to) wherein the at least one incident light waveguide (A) is one incident light waveguide (A), the at least one optical waveguide (a) is one optical waveguide (a), and the output light waveguides (B) are at least two in number (see claims 24 and 28).

The present invention is directed to a light branching optical waveguide and optical device using the same, as well as a method of manufacturing such light branching optical waveguide. Such waveguide and device are used in optical transmission systems, and there has been a growing demand for such systems with the recent widespread use of personal computers and the internet.

An optical branching circuit and an optical multiplexing circuit serving as basic elements are indispensable to in integrated optical circuit, and an optical waveguide branched to provide a Y shape has been conventionally known. A multi-mode interference type Y branch optical waveguide has been known, and various kinds of such multi-mode interference type Y branch optical waveguides have been proposed, as discussed in the paragraph bridging pages 4 and 5 of Applicants' specification.

However, various problems arise in connection with such multi-mode waveguides. For example, equal branching ratio of light is achieved only in the case where the mode of light propagating in the incident waveguide is a basic mode alone, where the basic mode is symmetric with respect to the central axis of the incident waveguide, where the central axis of the incident waveguide and that of the multi-mode waveguide coincide with each other, and where the multi-mode waveguide is of a shape symmetric with respect to its central axis. In the case where the intensity distribution of light propagating in an optical waveguide on an incident side is asymmetric with respect to the geometrical central axis of the optical waveguide, there arises a problem that the branching ratio of light cannot be equal. Moreover, it is noted that when the incident light waveguide has a curvature, the basic mode is generally asymmetric.

Furthermore, in a multi-mode type light branching optical waveguide, the position at which light of a basic mode and light of a higher-order mode interfere with

each other varies depending on a wavelength. Thus, there arises the additional problem that each of a loss of light intensity and a branching ratio is dependent on the wavelength. Accordingly, as the design of the multi-mode type light branching optical waveguide must be changed in accordance with the wavelength of the light, there arises a still further problem of, e.g., reduction of efficiency of production of the waveguide.

Against this background, and as described in the second full paragraph on page 7, and in the paragraph bridging pages 7 and 8 of Applicants' specification, the present inventors have found that a branch loss and a variation in branching ratio can be reduced by shifting the geometrical central axis of an incident light waveguide and the geometrical central axis of a multi-mode optical waveguide, and/or by making the core shape of the multi-mode optical waveguide asymmetric with respect to the geometrical central axis of the waveguide, even when the intensity distribution of light propagating in an optical waveguide on an incident side is asymmetric with respect to the geometrical central axis of the optical waveguide. Moreover, the present inventors have further found that such branch loss and variation in branching ratio can be suppressed, by making the core shape of the multi-mode optical waveguide asymmetric with respect to the geometrical central axis of the waveguide.

To emphasize, having investigated specific problems of branch loss and a variation in branching ratio, arising in connection with light branching optical waveguides using multi-mode optical waveguides and incident light waveguides wherein at least one of the incident light waveguides has a curved shape, Applicants have found structure which avoids these problems, achieving a light branching optical waveguide having a reduced branch loss and a reduced variation in branching ratio; and, additionally, provide structure wherein not only are such branch

loss and variation in branching ratio reduced, but the light branching optical waveguide has a small wavelength dependency.

Thus, Applicants have found that, with light branching optical waveguide structure including at least one incident light waveguide that is curved and a multi-mode optical waveguide, a branch loss and a variation in branching ratio can be reduced by an offset between the geometrical central axis of the incident light waveguide and the geometrical central axis of the multi-mode optical wavelength. Note the last full paragraph on page 16 of Applicants' specification.

Moreover, Applicants have also found, as a further feature of the present invention, that by forming the core shape of the multi-mode optical waveguide to be asymmetric with respect to the geometrical central axis of the multi-mode optical waveguide, light propagating in the multi-mode optical waveguide is provided with an intensity distribution having two nearly equal peaks, so that the branching of light at a branching ratio of 1:1 can be achieved.

In addition, as described in the paragraph bridging pages 19 and 20 of Applicants' specification, a low-loss, multi-mode, light branching optical waveguide having a reduced branch loss, a reduced variation in branching ratio and small wavelength dependence is achieved, where the extended line of the geometrical central axis of an incident light waveguide does not coincide with the geometrical central axis of the multi-mode optical waveguide, and the core shape of the multi-mode optical waveguide is asymmetric with respect to the geometrical central axis of the multi-mode optical waveguide. Note, in particular, the paragraph bridging pages 20 and 21 of Applicants' specification.

Thus, note that the light branching optical waveguide of the present invention has a function of achieving the branching of light to a branching ratio of 1:1 (equal) in the case that the light exhibits asymmetry in the incident waveguide. To accomplish

this, it is important to change asymmetric light of the optical waveguide (a) to a symmetric light. A problem to be solved by the present invention is changing an asymmetric light caused by optical waveguide (a), having the curved structure, to symmetric light. This problem is solved by the present invention; i.e., by providing the branching ratio between the quantities of light branched into the two output light waveguides to be substantially equal, this means that the intensity distribution of light has been changed to symmetrical distribution.

It must be emphasized that according to the present invention, a low-loss light branching optical waveguide having a reduced branch loss and reduced variation in branching ratio is provided, even though the intensity distribution of light propagating in an optical waveguide on an incident side is asymmetric with respect to the geometrical central axis of the optical waveguide, e.g., due to the use of the curved incident optical waveguide (a).

Okushima discloses an optical waveguide structure which includes a first optical waveguide, a second optical waveguide including a pair of optical waveguides, and an intermediate optical waveguide for connecting the first and second optical waveguides to each other, the intermediate optical waveguide being capable of propagating light of a high order mode therein. This patent further discloses that the intermediate optical waveguide may have an optical waveguide width greater than that of the first optical waveguide, or that the intermediate optical waveguide may have a refractive index higher than that of the first optical waveguide, or that the first optical waveguide and the intermediate optical waveguide may be arranged such that the center axes thereof are not aligned with each other, or that a connecting end portion of the first optical waveguide to the intermediate optical waveguide may be formed so as to have an asymmetrical refraction index distribution. Note column 3, lines 22-43. See also column 3, lines 18-21, describing

that the disclosed optical waveguide structure can realize a wavelength separation action of a high performance with the propagation loss of light reduced, in a construction in which no gap is produced between waveguides. See also the paragraph bridging columns 3 and 4 of this patent; and note also column 5, lines 21-27. This patent document further discloses that the intermediate optical waveguide 13 (note Fig. 1) is formed such that the optical waveguide width is greater than the optical waveguide width of the first optical waveguide 11, and the first optical waveguide 11 and the intermediate optical waveguide 13 are arranged such that center axes P and Q thereof may not be aligned with each other. See column 8, lines 47-52.

It is emphasized that the waveguide structure disclosed in Okushima functions so that combined light of light $\lambda 1$ and $\lambda 2$ are branched from each other respectively to output waveguides 12A and 12B, respectively. The intermediate optical waveguide 13 functions as a wavelength separation section which can propagate light of a high order mode therein. Note column 8, lines 23-38, of Okushima.

In contrast, and as discussed previously, the present invention structure is a low-loss light branching optical waveguide having a reduced branch loss and reduced variation in branching ratio notwithstanding that the intensity distribution of light propagating in an optical waveguide on an incident side is asymmetric. Such asymmetry arises, e.g., in connection with the present invention, with the at least one optical waveguide (a) having a curved structure. It is respectfully submitted that Okushima does not disclose, nor would have suggested, such structure as in the present claims, including the at least one optical waveguide (a) having a curved structure, problems arising in connection therewith, and avoidance of such problems as achieved by the present invention, including, e.g., wherein an extended line of the

geometrical central axis of the at least one optical waveguide (a) does not coincide with a geometrical central axis of the multi-mode optical waveguide (note, e.g., claims 1 and 21); and/or wherein a core shape of the multi-mode optical waveguide is asymmetric with respect to a geometrical central axis of the multi-mode optical waveguide (note, e.g., claims 2 and 25).

The contention by the Examiner that the at least one optical waveguide (11) in Okushima have a curved structure, the Examiner relying on Fig. 2 in Okushima, is respectfully traversed. Initially, it is emphasized that the drawings in Okushima are not engineering drawings; and, moreover, it is respectfully submitted that these drawings do not stand for the proposition raised by the Examiner. That is, it is respectfully submitted that the broken lines for the first waveguide (11) in Fig. 2 in Okushima are not intended to show a curved structure. This can be seen from Figs. 1, 2 and 4 of Okushima, described in column 7, lines 38-43, 47 and 48 as showing a schematic view of a same optical waveguide. It is respectfully submitted that the optical waveguide of Figs. 2 and 4 clearly do not look like they have a curved structure; and there is no description about a curved structure of the first waveguide (11) in Okushima. Taking the teachings of Okushima as a whole, as required under 35 U.S.C. §102 and 35 U.S.C. §103, it is respectfully submitted that this reference does not disclose, nor would have suggested, the presently claimed light branching optical waveguide, including, inter alia, the at least one incident optical waveguide having the curved structure, and with positioning of this at least one incident optical waveguide and/or with the core shape of the multi-mode optical waveguide, and advantages due thereto.

That Okushima discloses a different waveguide structure than that of the present claims can be seen in dimensions thereof as described in Okushima, as compared with those described and, in particular, claimed in connection with the

present invention (see especially claims 19 and 20). Thus, note that in Fig. 4 of Okushima, the length of the multi-mode optical waveguide is described as being 15,400 μm. Compare with that of the present invention, e.g., in Example 1 on pages 30 and 31, describing that the multi-mode optical waveguide has a length L of 220 μm.

In addition, note differences between offset distances in connection with the present invention, and in connection with Okushima. That is, note that in Okushima the offset distances are, e.g., 5 μm and 10μm, referring to Figs. 4 and 6 of Okushima. Such offset distances are different from that of the present invention, e.g., in claims 19 and 20, 1.5 μm or less, and 0.7 μm or less, respectively. Clearly, the teachings of the applied references, including Okushima, would have taught away from the present invention, including the offset distances as in claims 19 and 20.

In connection with claims 19 and 20, the Examiner contends in the paragraph bridging pages 7 and 8 of the Office Action mailed October 18, 2007, that it would have been obvious to one of ordinary skill in the art to offset the waveguides a specific amount to yield a desired branching ratio or optimum optical loss. In view of the large difference in offset distance recited in the present claims as compared with the offset distance in Okushima, as referred to previously, it is respectfully submitted that the disclosure in Okushima would have taught away from the presently claimed invention, including the offset distance, and function and advantage due thereto as achieved by the present invention.

It is respectfully submitted that the additional teachings of Ido would not have rectified the deficiencies of Okushima, such that the presently claimed invention as a whole would have been obvious to one of ordinary skill in the art.

Ido discloses an asymmetric Y branch optical waveguide having an input waveguide for entering light therein, two output waveguides for outputting the light therefrom and a multi-mode waveguide which is disposed between the input waveguide and the output waveguides and which generates a plurality of mode lights therefrom, and wherein the multi-mode waveguide is made asymmetric with respect to a center line extending in the direction of an optical axis. See column 2, line 52-60. See also the paragraph bridging columns 2 and 3 of this patent. This patent discloses a further embodiment of another asymmetric Y branch optical waveguide, which includes an optical waveguide for entering light therein, two output waveguides for outputting the light therefrom, and a multi-mode waveguide which is disposed between the input waveguide and the two output waveguides and which generates a plurality of mode lights therefrom, and wherein distances between sides of core portions of the multi-mode waveguide and a center line differ from each other at least at a portion with respect to the direction of traveling of the light. Note, column 3, lines 7-17. Note also column 9, lines 34-50.

Even assuming, arguendo, that the teachings of Ido and of Okushima were properly combinable, such combined teachings would have neither disclosed nor would have suggested the presently claimed invention, including use of the recited curved incident waveguide and problems arising in connection with use thereof, and avoidance of such problems through the presently claimed subject matter, as discussed previously.

Moreover, it is respectfully submitted that the Y-branch optical waveguide in Ido has a first optical waveguide (waveguide for input) in which the intensity distribution of light is symmetric, and second optical waveguides (waveguides for output) in which the intensity distribution of light is asymmetric.

In contrast, according to the apparatus of the present structure, and as in all of the present claims, the optical waveguide (a), having a curved structure, would have an asymmetric intensity distribution of light; and, more specifically, in the claimed device the optical waveguide (a) has a curved structure so that it can provide compact-sized circuits, this curved structure causing asymmetric intensity distribution of light at the portion where the optical waveguide (a) and the multi-mode optical waveguide are connected. According to the present invention, the intensity distribution of light is changed from asymmetric at the connecting surface between incident light waveguide (a) and the multi-mode optical waveguide, and the branching ratio between the quantities of light branched into the output optical waveguides (B) is equal (e.g., 1:1) at the portion where the optical output waveguides (B) and the multi-mode optical waveguide are connected, due to the present invention correcting asymmetric light to symmetric light.

Thus, while in Ido, the input optical waveguide has an intensity distribution of light that is symmetric and an optical waveguide for output in which the intensity of distribution of light is asymmetric, according to the present invention the intensity distribution of light is asymmetric at the input portion and is symmetric at the output of the multi-mode optical waveguide, opposite to that of Ido.

Clearly, Ido would have neither taught nor would have suggested, and in fact would have taught away from, the presently claimed structure and method, including the curved structure of the at least one optical waveguide (a) of the at least one incident optical waveguide (A); and since Okushima is silent as to a curved incident optical waveguide, as shown previously the combined teachings of these applied references would have taught away from this structure of the present invention, causing problems solved by the present invention.

Furthermore, it is respectfully submitted that the teachings of Okushima, either alone or in combination with the teachings of Ido, would have neither disclosed nor would have suggested the manufacturing process as recited in presently pending claims 21, 24, 25 and 28, including the positioning of the at least one optical waveguide (a) having the curved structure, and forming the core shape of the multi-mode optical waveguide wherein such multi-mode optical waveguide has at least one optical waveguide incident thereto that is curved, and advantages thereof as discussed previously.

In view of the foregoing comments and amendments, entry of the present amendments, and reconsideration and allowance of all claims presently pending in the above-identified application, are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 396.46073X00), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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Enclosure: Replacement Sheet 3/4 (Fig. 10)

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